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Design and Implementation of Ultrasonic Navigator for Visually Impaired

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Abstract: In this paper, we intend to provide a solution to the problems faced by the visually impaired people in navigating from one place to the other. Usually, a visually impaired person has to depend on the sense other than visualization such as hearing and touch to guide them. The traditional tool used by them is a walking cane. With this cane, they will be tapping around their surroundings to guide them. The ultimate result obtained by this process is inefficient because they will be able to detect the obstacles which are very close to them and also those which are below the chest level. The solution to these problems can be obtained using ultrasonic navigator. The information about the environment is obtained by using an ultrasonic sensor and the feedback is given using the servo motors mounted on the glove. The efficacy of the device and how humans respond to the feedback helps them to navigate through the complex environment. Also, our device has a Global Positioning System (GPS) system, which helps visually impaired person to reach the correct destination.

Key words: GPS · Arduino Uno · CASBliP · Ultrasonic waves · Haptic feedback

INTRODUCTION

Visual mutilation and blindness worry a momentous portion of the world population. It was reported by World Health Organization (WHO) that there were 161 million people who were visually impaired in the year 2002 [1]. Thus it can be noticed that there is an extensive need for inexpensive devices to assist the blind and visually impaired people. The visually impaired depend on their senses to navigate from one place to another. The senses mean to hear and touch. The sense of hearing helps them to gauge the distance and the sense of touch is the most important factor for a blind, allowing them to feel the object near them. The white cane or walking stick is the traditional and inexpensive tool used by blind people and they were developed after World War II [2]. Canes, however, will help in sensing the obstacles only in one direction. For example, a person walking with a cane will be able to detect only the obstacles which are very close to him and also which are below his chest level. Guide dogs can also be used by the blind people, but it requires $42,000 to train them [3]. These usages of white cane and guide dogs are also a physical indication to the society of their visual impairment.

There have been many Haptic devices developed for the visually impaired in the past. These devices differ mainly on the following factors: the region where they are mounted or worn, based on feedback that is delivered and the surroundings that are detected. Sharma, an Indian designer, created Le Chal- a haptic device that can be installed in a shoe [4]. This device is capable of receiving GPS information from a smart phone and provides feedback at the right, left, front and back of the shoe. A proximity sensor, which is installed in the front of the shoe, can detect objects up to 3 meters and provide vibrational feedback to the legs. This device is capable of sensing only low-level objects and since only 4 servo motors were used, conveying intermediate directions is not possible.

Cognitive Aid System for Blind People (CASBliP), a head mounted device, was developed by Santiago Praderas [5]. Two mounted cameras were used to provide stereo imaging and this is translated into audio which is played through headphones. This method allows detecting static objects that are between 0.5 to 15 m. The Haptic Alerts for Low-hanging Objects (HALO) is a device that was developed as an alternative to the traditional white cane [6]. This uses an ultrasonic range

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sensor to detect overhead objects and since it is worn on the head, the vibrations may damage the brain. The Tacit project was also developed as an alternative to the white cane but it was a wrist mounted device [7].There is a sensor-servo pair for each side of the hand to indicate direction by giving feedback to the hands. The servos rotation increase in frequency with closer distances. As the device is fixed to the hand, it allows for as many degrees of freedom that the hand has and allows the user in pointing in the interested direction.

A variety of parameters such as the type of sensor, mounting methods and feedback modes were considered while designing. The sensors should be able to detect objects at a distance greater than what a normal walking stick can detect. A length ranging anywhere from 25 – 63 inches (63 - 160 cm) is ideal [8]. Any object beyond this range causes confusion to the user and they provide unwanted information. A variety of sensing techniques were considered. Infrared rangefinders are prone to inaccurate readings in well-lit areas and hence they were not considered. A laser range finder could be used for its accuracy, but the cost of the sensor is too high and hence they were rejected. The sensing technique that was considered finally is Sound Navigation and Ranging (SONAR). It was considered because it has a range of 6 inches to 6 feet and its cost is only a little higher than the infrared sensors. Image based sensors were not considered due to their size and expense [9].

The haptic feedback largely depends on upon the information that is being conveyed, the quality of the information receptors and the space that is available. The servo motors are quite big and they add more weight to the device. More vibrations indicate a closer object and less vibration indicate a farther object. The frequency range that was selected is 10-500 Hz.

There are various mounting types that could be considered such as head mounting, wearing as a glove, embedding in a shoe etc. The head-mounted configuration could be dangerous, as it could damage the brain cells. The number of servo motors that is required, is significantly less in haptic feedback, as only the obstacle distance is to be conveyed to the user.

The goal of this paper is to develop a navigation assisting device to a blind person that would help him in sensing the surrounding environment through a sensor and convey that information to the user through servo motors. It also helps him in reaching the correct destination with the use of GPS system.

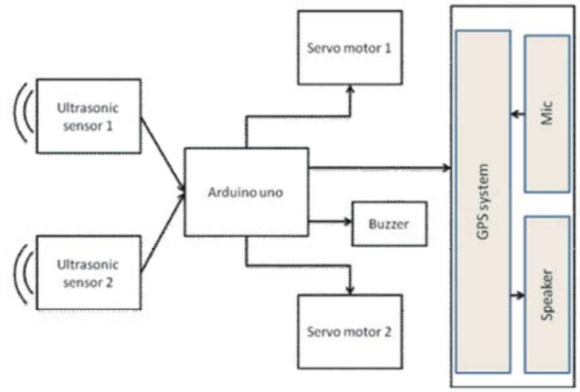

Fig. 1: System Model of proposed ultrasonic navigator

Fig. 2: Ultrasonic Sensor

System Model: The block diagram of proposed ultrasonic navigator consisting of two ultrasonic sensors, two servo motors, an arduino uno controller, a buzzer, a GPS board, a mic and a speaker is shown in Figure-1.

Ultrasonic Sensor: Its purpose is to measure the distance at which the obstacle is located. It sends the ultrasonic sound and receives the echo thereby giving the output pulse until the echo is detected. It is similar to SONAR, as the length of echo determines the distance of the object. But the disadvantage being that it cannot detect precisely small objects or those received from a shallow angle. Also soft obstacles that absorb waves are not sensed properly. The calculated distance also assumes that the temperature is constant.

The specifications of the ultrasonic sensor are as follows:

Supply voltage	:	+5V DC
Supply current	:	30 mA to 35 mA max
Communication	:	Positive TTL pulse
Package	:	3-pin SIP, 0.1 spacing (ground, power, signal)
Operating temperature	:	0 -70 C
Size	:	22 mmH x 46 mmW x 16 mm D (0.84 in x1.8 in x 0.6 in)

Fig. 3: Arduino Uno Microcontroller

Fig. 4: Servo Motor

Arduino Uno Microcontroller: Arduino software based on C++ is used for programming. The program is stored in EEROM which is interfaced through USB. An external power source of 9V is used to drive the controller. This is reduced to 5V DC by a voltage regulator. Two of the PWM pins are used to control the servo motors, two are used to receive inputs from the sensors, one pin used to ring the buzzer, one pin to mic for collecting destination location from the user and one analog pin to speaker for directing the user to reach the destination.

Servomotors: It is used for control of position, acceleration or velocity as it acts as a rotary or linear actuator. It is coupled to a sensor with a fitted controlled module. It gives out a corresponding pulse of variable width. A total of 180 degree movement; 90 degree on either direction is possible. At neutral, servo has equal amount of potential rotation in either direction. The pulse input is received for very 20ms and length of pulse will judge how fast the motor rotates. Servos will not hold their position for a long time and hence position pulse must be repeated to instruct the servo to stay in that position. The maximum amount of force the servo can put to resist migrating from a position is called torque rating of servo.

Fig. 5: Buzzer

Fig. 6: GPS module

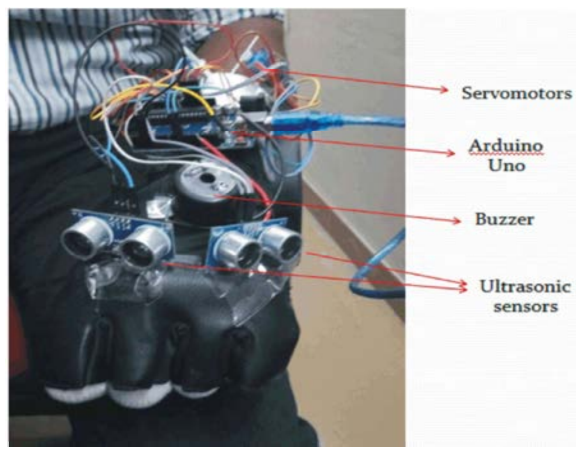

Fig. 7: Photograph of proposed Ultrasonic Navigator

Buzzer: It is a piezoelectric audio signaling device. It may also be a mechanical or electromechanical or electromagnetic audio device depending upon the usage.

The ring denotes that a button has been pressed. It produces the same noise irrespective of the variation of voltage applied in the range of 2 to 4kHz.

GPS module: This module is used along with arduino to guide the visually impaired to reach his correct destination. A mic is used to give the destination address to the GPS module and speaker is used to give instructions to the user.

Housing: All the above stated blocks are mounted on a glove to provide housing and also to protect it. The housing is very easy to wear and handle by the user [12]. The photograph of the housing is shown in the Figure-7.

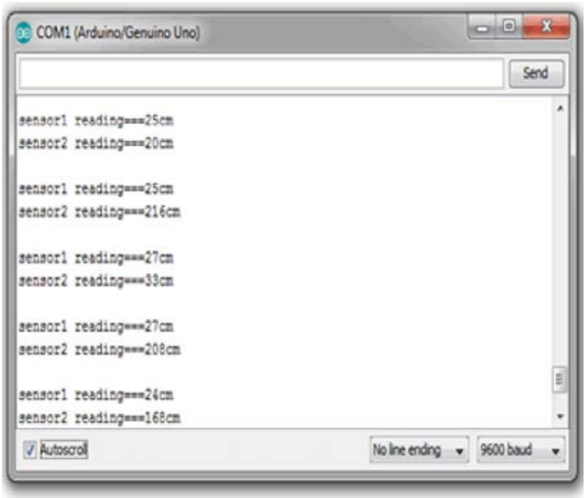

Fig. 8: Serial monitor

Implementation: A voltage source (Power bank) is used to turn on the vibrating motors, ultrasonic sensor and the piezoelectric buzzer which are connected to the arduino. The main loop runs only when the resistance of the voltage source is above or beyond the threshold, corresponding to value of 500 in the program. When the device is powered, 5V DC, ground and a control signal are given to the ultrasonic sensor. At this time the transmitter section of the ultrasonic sensor will transmit an ultrasonic wave and on hitting an obstacle it gets reflected back. This reflected wave is received by the receiver section in the ultrasonic sensor and ultimately it calculates the time taken by the wave to return back. The Arduino is programmed such that it will convert the time into equivalent distance in centimeters. Two such sensors will be used to detect both the left side as well as right side obstacles. The serial window monitor showing the measured distances at which the obstacles are present is shown in Figure-8.

The device then enters into a conditional loop to the check the closeness of the obstacles to the blind person. If the obstacle is too close; at distance less than 60cm as per the coding, then the corresponding servo motor will produce a haptic feedback on the hand of the blind person to indicate the presence of an obstacle. If the obstacle is too very close., at a distance less than 15cm as per the program, then the device will additionally ring the buzzer along with the frictional force on his hands to indicate that he is about to enter into a danger zone. Thus the device will create a tactile view of the surrounding to the person who wears these gloves. Also, the distance of detection can be varied up to 4 meters by varying the values in the program. The device will also direct the user to reach the correct destination with the help of a GPS system. The user has to press the reset button and speak out the destination location in mic provided in the device. The GPS system uses this information and the device directs the user using a speaker to reach his correct destination.

CONCLUSION

The results reveal that the haptic glove developed in this paper outperforms the traditional walking stick. The proposed ultrasonic navigator device can be used to navigate a complex environment with objects of varying height, hanging objects and even moving objects. The future work can address the following issues. The ultrasonic sensor's accuracy depends upon the temperature and thereby a sensor which works best with the changes in temperature has to be used. To indicate left and right directions, vibrations of different frequencies could be used. Low battery can also be indicated using vibration patterns. Rechargeable battery, solar cells, or piezoelectric generators can be used as voltage sources to charge the device. The components used in the device are prone to damage under conditions like rain, wind etc., there by the future designs should be made watertight. The distance of measurement depends upon the angle of approach and hence it must be made constant. Scaling factor and motor placement also plays a crucial part while testing. The error between the estimations and the actual distance could be recorded. The motor placement and scaling functions can be designed in such a way that there are more accurate corner guesses and the error is less. Thus the proposed Ultrasonic navigator device will serve as a great tool for the visually impaired people to navigate through complex environment.

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